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Washington, D. C. August, 1923

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THE WORK OF THE HUNTLEY RECLAMATION PROJECT EXPERIMENT FARM IN 1921.[1]

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INTRODUCTION.

THIS REPORT is one of a series published annually since 1912 on the results and progress of experiments at the Huntley Experiment Farm and gives also a brief statement of conditions and agricultural development on the Huntley Reclamation Project. The experimental work of the farm was continued as outlined in previous reports, with only slight modifications or additions. This work includes experiments in the production of both irrigated and dry-land field crops and also experiments in crop utilization through the use of livestock.

The experiments in crop production include rather extensive crop rotations and tillage experiments both on irrigated and on dry land, experiments with pasture grasses, varietal tests of grain and forage crops, tests of silage and root crops, and tests of fruit trees, small fruits, and vegetables.

In the crop-utilization experiments, work is conducted with dairy cattle and hogs. This work includes pasturing tests with dairy cattle, pasturing tests with hogs, methods of feeding dairy cattle on advanced registry test, and the dry-lot feeding of hogs.

[1] The Huntley Experiment Farm is located on the Huntley Reclamation Project in the Yellowstone Valley of Montana. The farm occupies about 300 acres of public land, the larger part of which is irrigated, and is maintained cooperatively by the Office of Western Irrigation Agriculture and the Montana Agricultural Experiment Station. Other offices and divisions of the United States Department of Agriculture in both the Bureau of Plant Industry and the Bureau of Animal Industry cooperate in the investigational work.

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CONDITIONS ON THE PROJECT.

CLIMATIC CONDITIONS.

The year 1921 was one of low total precipitation unequally distributed, so that there were long periods of drought. The total rainfall of 12.6 inches was 1.16 inches less than the annual average for the past 11 years. Owing to an almost total lack of rainfall during the preceding winter and early spring, the ground was in poor condition for spring seeding. This situation was relieved somewhat by heavy rains during the latter part of May and early June, which were sufficient to germinate seeds and insure good stands without resorting to irrigation for this purpose. The summer rainfall was light and of but little value to crops, since it usually occurred as torrential showers.

The frost-free period was 117 days, which was nine days less than the average for the 11-year period.

The winter was free from any extremely low temperatures and was generally open and mild. The mean temperature during the growing season was somewhat above normal. Although the growing season was short, most of the late crops were fairly well matured before the date of the first killing frost, which occurred on September 9.

The climatological observations for the 11-year period from 1911 to 1921, inclusive, are given in Table 1.

TABLE 1.—*Summary of climatological observations made at the Huntley Experiment Farm for the 11-year period from 1911 to 1921, inclusive.*

PRECIPITATION (INCHES).

Item.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average for 11 years, 1911 to 1921	0.61	0.34	0.77	0.96	2.38	2.37	1.26	0.75	1.43	1.27	0.87	0.75	13.76
For 1921	.25	.30	1.38	.72	3.85	2.19	.83	.19	.66	.21	1.72	.30	12.60

EVAPORATION (INCHES).

Average for 11 years, 1911 to 1921	.....	.....	.....	3.415	4.755	6.312	7.607	6.860	4.313	.....	.....	.....	33.262
For 1921	.....	.....	.....	4.043	4.246	5.720	7.379	7.351	4.990	.....	.....	.....	33.729

DAILY WIND VELOCITY (MILES PER HOUR).

Highest:													
1911 to 1921	22.2	14.1	13.3	17.8	17.5	10.2	27.5	7.3	10.5	29.4	25.0	26.6	.....
For 1921	12.1	12.0	10.1	15.4	11.8	7.2	27.5	5.5	8.8	7.2	6.9	9.4	.....
Lowest:													
1911 to 1921	.3	.8	.5	.9	.9	.4	.3	.3	.2	.8	.5	.1	.....
For 1921	1.6	1.6	.5	2.2	1.3	.9	.3	.4	.2	1.2	.8	1.2	.....
Mean:													
1911 to 1921	5.5	4.7	4.4	5.5	5.1	3.9	3.4	3.3	3.8	4.0	4.3	4.9	.....
For 1921	4 4	5.1	5.3	6.0	5.0	2.7	3.5	2.8	4.7	3.2	3.4	4.4	.....

TEMPERATURE (°F.).

Absolute maximum:													
1911 to 1921	65	70	74	87	99	107	105	103	94	90	75	63	.....
For 1921	63	70	69	80	81	92	105	99	88	87	75	58	.....
Absolute minimum:													
1911 to 1921	−39	−38	−37	12	22	32	38	34	24	−10	−28	−41	.....
For 1921	2	−18	−10	18	28	40	43	40	24	18	−28	−14	.....
Mean:													
1911 to 1921	19	23	32	45	53	64	71	68	57	45	33	22	.....
For 1921	28	31	34	44	53	67	71	71	55	50	29	21	.....

TABLE 1.—*Summary of climatological observations made at the Huntley Experiment Farm for the 11-year period from 1911 to 1921, inclusive*—Continued.

KILLING FROSTS.

Year.	Last in spring.		First in autumn.		Frost-free period (days).
	Date.	Minimum temperature (°F.).	Date.	Minimum temperature (°F.).	
1911	May 26	32	Sept. 18	28	114
1912	May 12	28	Sept. 15	31	125
1913	May 5	31	Sept. 19	29	136
1914	May 12	32	Oct. 6	31	146
1915	May 21	32	Sept. 19	32	120
1916	May 16	30	Sept. 13	31	119
1917	May 31	31	Sept. 28	32	119
1918	May 21	32	Oct. 7	28	138
1919	May 7	29	Sept. 27	32	142
1920	June 3	32	Sept. 24	32	112
1921	May 14	32	Sept. 9	32	117
Average	May 18	.....	Sept. 22	.....	126

CROP CONDITIONS.

According to the annual crop census of the United States Reclamation Service, the total cropped area of the Huntley project in 1921 was 18,784 acres. Alfalfa, which is the most important crop of the project in point of acreage, occupied 5,538 acres, or nearly one-third of the cropped area. Wheat ranked second in importance, with an acreage nearly as great, followed by sugar beets, of which there were 3,178 acres. The remaining acreage was divided between oats, pasture, corn, barley, and other miscellaneous crops of minor importance. The acreage, yields, and values of crops on the Huntley project in 1921 are given in Table 2, and the same data for the nine-year period, 1913 to 1921, inclusive, are given in Table 3. These tables were compiled from crop reports furnished by the United States Reclamation Service.

While alfalfa ranked in importance in 1921 about the same as in previous years, the yield of 1.73 tons per acre was nearly 1 ton less than the average for the nine-year period. This low yield was due in part to poor stands but to a larger extent to the effects of hail damage and grasshopper invasion. On parts of the upper end of the project the first crop of alfalfa was almost a total loss as the result of a severe hailstorm which occurred on June 1, and yields of the second and third crops were materially decreased as a result of grasshopper damage. The season's production of this crop was barely sufficient to meet local requirements. While the farm value of the crop is given as $7.97 a ton, this price represents the selling value at the end of the harvest season, the price advancing to $15 per ton later in the year.

Sugar beets yielded in 1921 at the rate of 10.04 tons per acre, which was nearly 1 ton per acre higher than the average of the nine-year period. The acreage devoted to this crop was greater than in any year since 1917, although much less than for several years previous to that time. This crop reached its greatest importance in 1915, in which year more than 5,000 acres were grown. In the three years following, the acreage was decreased until in 1919 it was only slightly over 1,000 acres. The high price received for wheat during

this period was largely responsible for this decrease, wheat replacing sugar beets to a large extent as the cash crop during this time. While it is doubtful whether the beet crop will regain its former maximum position, it will in all likelihood continue to be an important crop on the project.

TABLE 2.—*Acreage, yields, and farm values of crops produced on the Huntley Reclamation Project in 1921.*

Crop.	Area (acres).	Unit of yield.	Yields.			Farm values.		
			Total.	Per acre.		Per unit of yield.	Total.	Per acre.
				Average.	Maximum.			
Alfalfa hay	5,538	Ton	9,564	1.73	5	$7.97	$76,234	$13.78
Alfalfa seed	31	Bushel	136	4.39		4.46	607	19.59
Barley	247	...do	5,906	23.91	80	.46	2,707	10.96
Beets, sugar	3,178	Ton	31,924	10.04	17	6.78	216,445	68.07
Clover hay	32	...do	34	1.06	2	7.44	296	9.23
Clover seed	100	Bushel	168	1.68	6	4.43	744	7.44
Corn	375	...do	7,307	19.51	55	.68	4,991	13.31
Garden	139						11,939	85.18
Oats	1,630	Bushel	35,191	21.58	70	.398	13,873	8.51
Pasture, summer	1,479						7,981	5.40
Pasture, winter	15,476						23,483	1.52
Potatoes	185	Bushel	18,500	100	400	.814	15,065	81.43
Wheat	5,469	...do	93,684	17.12	40	1.01	94,521	17.29
Miscellaneous	379						4,974	13.15
Alfalfa	22						(1)	
Barley	24						(1)	
Beets, sugar	43						(1)	
Corn	14						(1)	
Oats	72						(1)	
Wheat	30						(1)	
Total	18,782						473,860	
Average								25.23

[1] No crop value, although included in above report.

Of the crops other than wheat, beets, and oats there were no significant changes in relative importance during the nine-year period. The acreage planted to oats has decreased each year since 1913, falling from nearly 4,000 acres in 1913 to about 1,600 acres in 1921. This crop was commonly grown the first year after the land was broken up from native sod, and this probably accounts for the high acreage during the earlier years. Potatoes have never been grown extensively on the project and it would appear that this crop might be increased to advantage, since excellent yields are reported and some of the project lands, especially the lighter soils along the river, appear to be especially well suited to the cultivation of this crop. While the market for this crop is somewhat uncertain and the price varies widely from year to year, the growing of one or two standard varieties in quantities sufficient to attract buyers would probably do much to overcome this difficulty.

The use of irrigated pastures is increasing to some extent on the project, and while some difficulty has been experienced in the past two or three years in securing stands because of drought and unfavorable weather conditions, such pastures as have been established appear to be giving very satisfactory returns. Irrigated pastures when well established on good land have a carrying capacity of from one and one-half to two cows per acre during a period of from four and one-half to five months.

Table 3 indicates that the average farm values of crops on the Huntley project in 1921 were less than in any year during the nine-year period. This was due to a combination of low crop yields and relatively low prices received and was affected to a large extent by the low yields of alfalfa hay. The top point in value of crops was reached in 1919.

TABLE 3.—*Summary of acreage, yields, and farm values of the principal crops grown on the Huntley Reclamation Project from 1913 to 1921, inclusive.*

Item and year.	All crops.	Alfalfa hay.	Barley.	Sugar beets.	Corn.	Oats.	Summer pasture.	Winter pasture.	Potatoes.	Wheat.
Acreage:										
1913	15,798	4,848	191	4,475	326	3,942	.....	.....	99	1,177
1914	17,068	6,038	363	4,274	497	3,226	.....	.....	120	1,663
1915	18,203	5,287	415	5,402	509	2,514	1,478	.....	80	2,869
1916	18,581	5,422	298	5,264	174	2,628	1,393	.....	54	2,624
1917	19,104	6,002	109	3,366	186	2,420	1,451	.....	164	4,330
1918	19,265	6,766	75	1,963	203	2,006	1,091	.....	73	6,306
1919	19,310	7,045	267	1,136	179	1,977	1,389	16,733	40	6,518
1920	20,021	7,468	324	2,330	392	1,764	2,074	15,550	78	5,098
1921	18,782	5,538	247	3,178	375	1,630	1,479	15,476	185	5,469
Production:		*Tons.*	*Bus.*	*Tons.*	*Bus.*	*Bus.*			*Bus.*	*Bus.*
1913	.....	16,725	2,535	45,511	5,418	113,766	.....	.....	11,889	21,410
1914	.....	17,440	6,689	41,030	11,755	96,014	.....	.....	10,680	39,095
1915	.....	15,010	8,196	53,911	9,258	75,319	.....	.....	9,360	56,863
1916	.....	14,411	2,239	42,106	1,732	37,795	.....	.....	5,155	31,161
1917	.....	14,062	1,304	28,553	3,497	70,470	.....	.....	21,272	83,450
1918	.....	17,234	1,883	16,299	4,263	73,080	.....	.....	9,612	138,305
1919	.....	18,713	5,354	12,015	5,046	58,707	.....	.....	4,781	103,149
1920	.....	16,962	4,816	14,814	4,441	40,960	.....	.....	6,449	83,549
1921	.....	9,564	5,906	31,924	7,307	35,191	.....	.....	18,500	93,684
Average yield per acre:										
1913	.....	3.45	13.27	10.17	16.62	28.86	.....	.....	120.10	18.19
1914	.....	2.90	18.40	9.60	23.75	29.80	.....	.....	89.00	23.50
1915	.....	2.82	19.75	9.98	18.19	29.96	.....	.....	117.00	19.82
1916	.....	2.66	7.50	8.00	9.97	14.38	.....	.....	95.02	11.87
1917	.....	2.34	12.00	8.48	18.78	29.11	.....	.....	130.00	19.25
1918	.....	2.55	25.11	8.30	21.20	36.43	.....	.....	132.12	21.93
1919	.....	2.65	20.05	10.58	28.19	29.69	.....	.....	119.70	15.82
1920	.....	2.27	14.82	6.36	11.33	23.22	.....	.....	82.68	16.38
1921	.....	1.73	23.91	10.04	19.51	21.58	.....	.....	100.00	17.12
Farm value per unit of yield:										
1913	.....	$5.50	$0.48	$6.00	$1.05	$0.32	.....	.....	$0.45	$0.66
1914	.....	5.00	.53	.00	.62	.32	.....	.....	.62	.98
1915	.....	5.76	.53	5.92	.80	.49	.....	.....	.72	.87
1916	.....	8.95	.92	6.08	.86	.63	.....	.....	1.14	1.46
1917	.....	14.70	1.20	7.27	1.46	.78	.....	.....	.77	1.88
1918	.....	11.99	.98	10.00	1.25	.79	.....	.....	.69	1.94
1919	.....	19.66	1.68	10.00	1.53	1.16	.....	.....	1.77	2.37
1920	.....	7.90	.89	12.00	.81	.67	.....	.....	1.11	1.44
1921	.....	7.97	.46	6.78	.68	.40	.....	.....	.81	1.01
Farm value per acre:										
1913	$29.35	18.79	6.37	61.02	17.45	9.24	.....	.....	54.04	12.00
1914	26.63	14.45	9.75	57.60	14.65	9.54	.....	.....	55.18	23.03
1915	29.41	16.20	10.47	59.08	14.55	14.68	$3.76	.....	84.24	17.24
1916	26.32	23.84	6.93	48.61	8.62	9.00	6.36	.....	108.55	17.35
1917	36.16	34.46	14.42	61.66	27.39	22.69	6.36	.....	99.65	36.22
1918	39.00	30.57	24.71	83.00	26.50	28.86	9.70	.....	90.93	42.60
1919	49.14	52.22	33.69	105.77	43.11	34.40	11.94	$3.94	211.55	37.51
1920	27.11	17.94	13.23	76.29	9.18	15.55	8.74	1.82	91.77	23.54
1921	25.23	13.78	10.96	68.07	13.31	8.51	5.40	1.52	81.43	17.29
Total farm values:										
1913	463,697	91,987	1,216	273,066	5,688	36,405	.....	.....	5,350	14,130
1914	454,583	87,200	3,545	246,180	7,288	30,724	.....	.....	6,622	38,313
1915	535,363	86,458	4,344	319,153	7,406	36,906	5,557	.....	6,739	49,471
1916	489,071	129,263	2,068	255,826	1,496	23,651	8,867	.....	5,889	45,529
1917	690,760	206,838	1,568	207,562	5,101	54,915	9,237	.....	16,301	156,838
1918	750,964	206,712	1,854	162,990	5,381	57,899	10,588	.....	6,616	268,616
1919	948,968	367,898	8,995	120,150	7,720	68,000	16,580	65,834	8,462	244,464
1920	543,781	134,000	4,289	177,769	3,597	27,443	18,136	28,301	7,158	120,041
1921	473,860	76,234	2,707	216,445	4,991	13,873	7,981	23,483	15,065	94,521

CONDITIONS RELATING TO LIVESTOCK.

The number of all classes of livestock kept on the Huntley project farms is given in Table 4. This table shows that there was a slight decline in the number of all the important classes of stock during this time and also that there was a decided decrease in the value of such stock. In Table 5 are given the number and value of livestock kept on the project each year from 1914 to 1921, inclusive.

TABLE 4.—*Livestock on the Huntley Reclamation Project in 1921.*

Item.	Inventory, Jan. 1.			Inventory, Dec. 31.			Increased or decreased total value.
	Number.	Average value.	Total value.	Number.	Average value.	Total value.	
Horses	2,041	$88.90	$181,445	1,865	$64.53	$120,340	−$61,105
Mules	34	94.40	3,210	58	82.44	4,782	1,572
Cattle:							
Beef	1,312	42.90	56,416	1,765	26.00	45,906	−10,510
Dairy	1,804	63.45	114,464	1,542	43.39	67,913	−46,551
Sheep	2,382	6.19	14,745	1,486	4.00	5,944	−8,801
Hogs	1,885	11.15	21,018	1,365	8.00	10,920	−10,098
Fowls	18,232	.69	12,680	18,500	.56	10,360	−2,320
Bees, hives	180	7.30	1,314	442	6.12	2,705	1,391
Total			405,292			268,870	−$136,422

TABLE 5.—*Numbers and value of livestock kept on farms on the Huntley Reclamation Project during the period from 1914 to 1921, inclusive.*

Livestock.	1914	1915	1916	1917	1918	1919	1920	1921
Number:								
Horses	2,008	1,961	1,961	2,145	2,120	2,297	2,041	1,865
Mules	53	53	58	80	51	46	34	58
Cattle:								
Beef	2,921	3,316	1,982	1,795	1,813	2,631	1,312	1,765
Dairy			1,753	1,949	1,920	2,040	1,804	1,542
Sheep	847	6,198	3,729	1,974	1,130	2,115	2,352	1,486
Hogs	4,612	4,866	2,791	2,363	2,391	3,097	1,885	1,365
Fowls	23,345	18,758	16,418	16,920	15,856	21,456	18,232	18,500
Bees, hives	249	288	282	296	424	458	180	442
Average value of each:								
Horses	$108.88	$117.37	$124.00	$131.73	$108.70	$110.00	$88.90	$64.53
Mules	134.90	135.09	138.00	134.56	107.16	81.50	94.40	82.44
Cattle:								
Beef	47.45	47.05	42.00	47.51	51.03	47.70	42.90	26.00
Dairy			64.00	54.02	60.18	62.30	63.45	43.39
Sheep	3.22	4.71	5.80	8.13	13.41	8.40	6.19	4.00
Hogs	9.68	5.51	8.00	15.40	18.07	13.64	11.15	8.00
Fowls	.49	.50	.54	.61	.52	.66	.69	.56
Bees, hives	3.07	5.09	3.33	3.17	3.78	5.35	7.30	6.12
Total value:								
Horses	218,640	230,175	243,095	282,570	230,435	252,670	181,445	120,340
Mules	7,150	7,160	7,990	10,765	5,465	3,749	3,210	4,782
Cattle:								
Beef	138,625	156,023	82,337	82,060	92,517	125,498	56,416	45,906
Dairy			11,881	105,290	115,726	127,092	114,464	67,913
Sheep	2,730	29,199	21,578	16,064	15,153	17,766	14,745	5,944
Hogs	44,536	26,822	22,328	36,365	43,205	42,242	21,018	10,920
Fowls	11,356	9,379	8,900	10,343	8,245	14,162	12,680	10,360
Bees, hives	758	1,467	939	940	1,603	2,450	1,314	2,705

Of the livestock industries, dairying is the most important. The difference in the number of dairy cattle from year to year was not great, although the largest number was reported in 1919 and the smallest in 1921. There was apparently a steady decline in the

number of hogs since 1914, the only exception to this being a slight increase in the number in 1919. The rather high cost of marketing and the relatively low price received for pork products in recent years have been responsible for this decrease. More sheep were kept in 1915 and 1916 than in any year since that time, these sheep being brought in principally from outside ranges for winter feeding.

CROP-ROTATION EXPERIMENTS.[2]

In 1912 an extensive series of experiments with various crop rotations under irrigation was begun. These experiments have been conducted each year on 70 quarter-acre plats in field K. In 1916 these investigations were enlarged by the addition of 27 quarter-acre plats in field L–IV.[3] The experiments include seven of the important crops of the Huntley project. These seven crops are grown in eleven 2-year, five 3-year, four 4-year, and six 6-year rotations. In addition, there are 14 plats devoted to growing each of the crops continuously on the same land in order that some comparison may be made between crop rotation and continuous cropping.

TABLE 6.—*Average, maximum, and minimum yields of all crops in the irrigated rotations on the Huntley Experiment Farm in 1921, compared with the average yields of the same crops in the 8-year period from 1913 to 1920, inclusive.*

Crop and variety.	Number of plats.	Unit of yield.	Yield per acre.										
			1921			1920	1919	1918	1917	1916	1915	1914	1913
			Maximum.	Minimum.	Average.								
Alfalfa (Grimm):													
Spring seeded.	5	Ton....	1.67	1.12	1.27	1.87	1.25	2.22	2.03	2.07	2.34	2.21	2.20
Fall seeded...	4	...do...	1.98	1.72	1.88	3.38	2.63	3.17	3.42	.....	.....	.....	.....
Second year..	9	...do...	4.62	2.32	3.39	4.59	6.09	5.34	5.71	5.26	7.14	5.40	5.86
Third year...	[a] 5	...do...	3.53	2.56	2.98	5.68	4.24	6.13	5.38	6.26	7.00	5.26	5.35
Continuous cropped....	5	...do...	3.40	2.27	2.82	4.65	5.77	5.45	4.65	4.98	4.72	4.62	4.51
Sugar beets (Kleinwanzlebener).....	19	...do...	14.77	5.48	10.79	7.63	10.15	12.23	9.82	11.17	9.58	11.16	13.08
Potatoes (Mills Prize).....	17	Bushel.	358.0	105.3	232.5	136.4	249.3	367.6	218.2	240.3	301.8	167.8	212.7
Oats (Swedish Select).....	21	...do...	91.1	27.1	67.9	63.6	52.7	90.7	75.0	78.2	79.3	89.8	84.2
Wheat (Pringle Champlain)....	5	...do...	33.6	14.7	21.0	26.3	27.3	23.9	26.5	26.4	32.3	32.7	27.2
Corn (Northwestern Dent).....	[b] 8	...do...	74.4	23.7	49.2	47.9	42.7	45.9	32.6	36.3	36.9	42.9	42.0
Flax (Minnesota No. 25).....	2	...do...	12.8	3.4	8.1	12.0	8.5	20.2	18.9	17.7	21.3	18.6	21.7

[a] Two of the third-year plats are "hogged off"; the average given is for three plats.
[b] Three of the corn plats are estimated.

The purpose of these experiments is to determine (1) the effect of crop sequences, (2) value of alfalfa in a rotation, (3) the effect of manure in a rotation, (4) the effect of a cultivated crop in a rotation, and (5) to compare the rotation of crops with continuous cropping.

In Table 6 are given the average yields of each crop for each year from 1913 to 1920, inclusive. This table also shows the maximum, minimum, and average yields of each crop obtained in 1921.

[2] This report was prepared by John W. Bowen, who had charge of the irrigated rotation experiments.
[3] The arrangement of the fields and location of the experiments referred to in the text are shown in Figure 1, a map of the Huntley Experiment Farm.

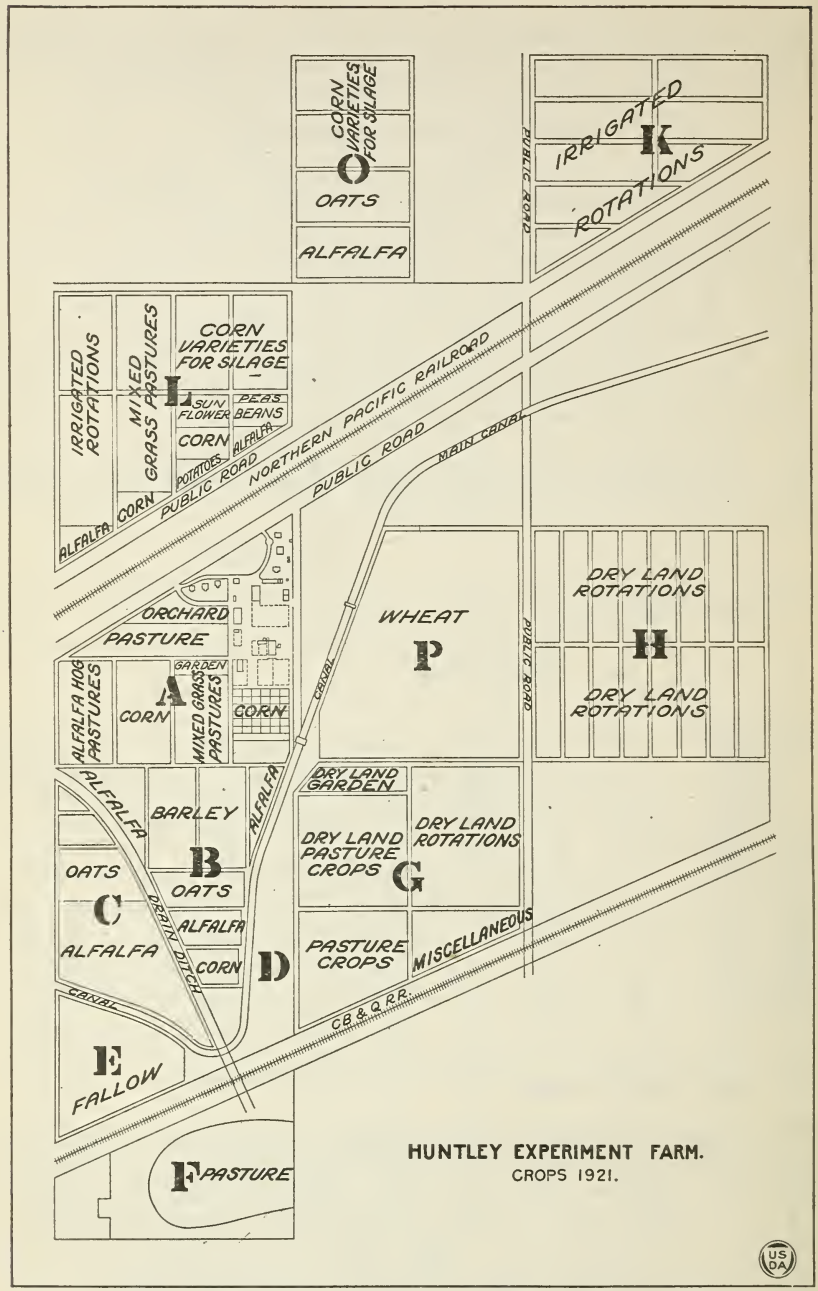

FIG. 1.—Diagram showing the arrangement of the fields and the location of the experiments at the Huntley Experiment Farm in 1921.

Though the work has not progressed far enough to warrant the drawing of definite conclusions as to the relative merits of the various rotations, the nine-years' results have given some indications of the effects of the various crop sequences and the value of alfalfa, manure, and cultivated crops in a rotation and also the value of crop rotations as compared with a system of continuous cropping.

A wide variation has occurred each year between the maximum and minimum yields of each crop. The maximum yields have usually occurred in some rotation which includes alfalfa or manure, and the minimum yields are most frequently found in continuously cropped plats or in crops included in the shorter rotations.

Alfalfa yields in 1921, with the exception of the spring-seeded plats, were the smallest that have been obtained since these experiments were begun. This reduction was due to the almost total loss of the first cutting of alfalfa by hail on June 1 and damage to subsequent cuttings by grasshoppers.

The maximum yield of oats obtained in 1921 in these rotations was 91.1 bushels per acre, while the minimum was 27.1 bushels per acre. For the 21 plats of oats an average return of 67.9 bushels per acre was received. The 91.1 bushels yield was made in a two-year rotation where oats followed sugar beets. In all cases oats produced the highest yields in rotations where this crop followed a cultivated crop or in a rotation which included alfalfa or a manured crop.

Though the average yield of oats for 1921 was somewhat higher than the average yields for 1919 and 1920, it was less than the yearly averages of the years 1913 to 1918, inclusive.

Potatoes produced the highest yields in six-year rotations in which potatoes follow alfalfa. The average for all plats in 1921 was 232.5 bushels per acre. Yields ranged from a minimum of 105.3 bushels to a maximum of 358 bushels per acre. The average for the past season closely approximated the average yields received since 1913.

The 1921 maximum yield of sugar beets was 14.77 tons per acre. This occurred in a two-year rotation where sugar beets follow potatoes, and manure was used. The minimum yield of 5.48 tons per acre was produced in a three-year rotation in which sugar beets followed oats. The average for all plats was 10.79 tons per acre, which compared favorably with the averages obtained during the past eight years.

Five plats of wheat produced a range in yields from 14.7 to 35.6 bushels per acre, with an average for the season of 21 bushels. This average is the lowest that has been recorded since the experiment was begun.

The yields of corn from all plats averaged 49.2 bushels per acre, which was somewhat higher than has been obtained heretofore. The minimum return was 23.7 bushels per acre, while the maximum was 74.4 bushels per acre.

Flax yields were comparatively low, the two plats making 3.4 bushels per acre and 12.8 bushels per acre, with an average of 8.1. This is four-tenths of a bushel less than the yearly average since 1913.

In Table 7 are presented the yields of oats, potatoes, and sugar beets, as obtained from each rotation and following the crops shown.

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TABLE 7.—*Yields per acre of oats, potatoes, and sugar beets, following stated crops in the irrigated rotations on the Huntley Experiment Farm in 1921.*

Oats.			Potatoes.			Sugar beets.		
Preceding crop.	Rotation No.	Yield.	Preceding crop.	Rotation No.	Yield.	Preceding crop.	Rotation No.	Yield.
		Bush.			*Bush.*			*Tons.*
Beets	22	91.1	Alfalfa	60	358.0	Potatoes	35	14.77
Do	46	85.9	Do	61	341.2	Do	21	14.66
Corn (hogged)	69	85.5	Do	64	310.6	Alfalfa	46	14.49
Potatoes	61	80.8	Potatoes	4a	272.6	Oats (manured)	61	14.44
Do	60	80.1	Alfalfa	40	268.6	Potatoes	64	14.19
Beets	64	79.4	Oats (manured)	35	258.6	Flax	67	13.58
Potatoes	25	76.1	Beets	20	251.3	Potatoes	40	12.67
Beets	34	75.8	Oats (manured)	25	239.3	Do	20	12.49
Potatoes	44	75.0	Oats	34	226.6	Do	34	10.91
Do	24	74.1	Beets (manured)	21	226.0	Oats (manured)	23	10.79
Beets	35	73.1	Beets	30	220.6	Beets	2a	10.57
Alfalfa	42	73.0	Alfalfa	44	212.6	Oats	60	9.49
Beets	23	66.4	Corn	26	178.0	Do	42	9.17
Corn	16	66.4	Beets	31	169.3	Oats (manured)	31	8.51
Potatoes	31	60.5	Oats	24	180.7	Beets	2	8.40
Do	27	59.1	Potatoes	4	132.6	Oats	22	6.90
Do	30	58.8	Oats (rye)	27	105.3	Do	32	6.79
Corn	32	48.6				Wheat	18	6.65
Wheat	28	48.4				Oats	30	5.48
Oats	1a	40.7						
Do	1	27.1						
Average		67.9	Average		232.5	Average		10.79

The two highest yields of oats in 1921 were obtained where the crop followed sugar beets, while the lowest return was received from land which has been continuously cropped to oats since 1913.

Potatoes after alfalfa gave the three highest yields per acre, while the minimum yield was obtained in a two-year rotation where the potatoes were grown on land which had been in oats during 1920, seeded to winter rye following the removal of the oats, and the winter rye plowed under in the spring of 1921 to make a seed bed for potatoes.

Sugar beets after potatoes returned the maximum yields, but these were closely followed by rotations in which alfalfa or a manured crop occurred. The outstanding low yields of sugar beets were obtained on land which had produced oats or wheat during the previous year.

The average yields of oats, potatoes, and sugar beets for the nine-year period, 1913 to 1921, inclusive, together with the results obtained in 1921, are presented in Table 8. The data are arranged so as to present the yields for the nine-year average in descending order. The number of plats used each year and the immediately preceding crops are also shown. This permits a comparison of the yields obtained following the various crops and cultural methods.

A nine-year average yield of 91.1 bushels per acre of oats has been obtained on land producing corn harvested by hogs the previous year. This is closely followed by the average yield of oats after sugar beets. The average minimum production of oats has been from land which has been grown to oats continuously.

The highest average yield of potatoes for the period, 1913 to 1921, inclusive, has been obtained from potatoes after oats (manured) and the minimum yield from a rotation in which the crop was grown after oats with rye plowed under preceding the planting of the potatoes.

TABLE 8.—*Average yields per acre of oats and potatoes in bushels and sugar beets in tons for the nine years from 1913 to 1921, inclusive, together with the number of plats used each year, the preceding crop for each year, and the yields per acre obtained in 1921 at the Huntley Experiment Farm.*

Oats.				Potatoes.				Sugar beets.			
Preceding crop.	Number of plats.	Average, 9 years.	Yield, 1921.	Preceding crop.	Number of plats.	Average, 9 years.	Yield, 1921.	Preceding crop.	Number of plats.	Average, 9 years.	Yield, 1921.
Corn (hogged)	1	91.1	85.5	Oats (manured).	2	312.0	249.0	Flax	1	13.74	13.58
Beets	6	88.0	78.6	Alfalfa	5	273.3	298.2	Potatoes	6	12.20	13.28
Alfalfa	1	85.0	73.0	Beets (manured).	1	253.0	226.0	Oats (manured).	3	11.79	11.25
Potatoes	8	77.4	70.6	Oats	2	245.9	203.7	Alfalfa	1	9.68	14.49
Corn	2	62.1	57.5	Corn	1	216.8	178.0	Beets	2	9.24	9.49
Wheat	1	47.6	48.4	Beets	3	208.6	213.7	Oats	5	9.08	7.57
Oats	2	47.2	33.9	Potatoes	2	189.9	213.7	Wheat	1	7.82	6.65
				Oats (rye)	1	94.5	105.3				

Sugar beets preceded by flax have averaged more tons per acre than the other methods used during the past nine years, while the minimum average yield has been obtained from a rotation in which the beets are preceded by wheat.

SILAGE CROPS.

CORN.

In tests of corn varieties for silage it has been considered that only such varieties as would mature fully were suitable for this purpose. The tests conducted in previous seasons were confined to such varieties as were known from long experience to mature in the comparatively short season of the locality. The yields of silage from such varieties were all comparatively low and under the most favorable conditions were seldom more than 10 tons per acre. Of these early varieties Northwestern Dent has heretofore been recommended as superior to any of the others in point of total yield. In tests of so-called fodder or silage corn it was found that none of these reached a stage of maturity necessary to make silage of good quality, although the yields were much higher than of the varieties that matured.

In a test of varieties in 1921 two varieties, Paynes White Dent and Calico, gave yields higher than Northwestern Dent, and both were sufficiently matured to make silage of good quality. The yield of Calico was at the rate of 11.55 tons per acre, of Paynes White Dent 9.7 tons, and of Northwestern Dent 7.9 tons. In each case these yields are the average of eight quarter-acre plats. The variety Paynes White Dent was fully as well matured as was the Northwestern Dent at the time of harvest, which was on September 10. The Calico was slightly less matured, although the grain was beginning to dent and was considered to be sufficiently advanced to make silage of a fairly good quality. The Paynes White Dent was grown from seed produced in western South Dakota and the Calico from seed grown in western Nebraska.

SUNFLOWERS.

In experiments with sunflowers at the Huntley Experiment Farm during previous years all efforts to make silage of satisfactory quality have been unsuccessful, although excellent yields of this crop were produced. This failure to make good silage has apparently been due to a deficiency of fermentable sugar in the plants grown in this locality, since in other sections of the State, especially in the higher mountain valleys where sunflower silage of good quality was produced, it was found that the plants were of much higher sugar content.

An experiment was conducted in 1921 to determine the effect of adding sugar-containing materials to the silage made from sunflowers. It was found that sunflowers and corn in equal proportions made silage of a good quality, the corn apparently containing sufficient sugar to cause proper fermentation in the mixture. The addition of 3 per cent sugar in the form of sugar-beet molasses to sunflowers made silage of fairly good quality. Sugar in other forms such as sugar beets when added to sunflowers also produced proper fermentation, so that silage of fair quality resulted. In this experiment the silage was put up in small amounts in barrels and no feeding tests were made of the material.

INVESTIGATIONS IN DRY-LAND AGRICULTURE.[4]

The investigational work in dry-land agriculture was continued at this station in 1921 along the same general lines as during the previous nine years.

The experiments with crops include an extensive series of rotations in which winter wheat, spring wheat, oats, barley, flax, corn, peas, rye, sweet clover, alfalfa, and brome-grass are grown in various combinations and with several cultural systems, including spring plowing, fall plowing, summer fallowing, and "stubbling in." A comparison of tillage methods including several treatments of summer fallow, manuring, spring and fall plowing, subsoiling, and listing is also being carried on. In connection with the rotation and cultural experiments, studies of the soil moisture are made during the growing season. A series of variety tests with potatoes, grains, beans, garden vegetables, and forage crops has also been conducted.

Experiments in pasturing a number of grain and forage crops with hogs, which have been carried on since 1915, were continued during the past season. Winter rye, peas, barley, and corn in rotation and alfalfa and brome-grass on permanent plats are grazed off in these tests. The results obtained from pasturing these crops are compared with yields received from harvesting similar plats by machinery.

Though climatic conditions during this past season did not deviate greatly from the average when considered as a whole, their combination together with an extremely low soil-moisture reserve in the spring characterized the season as one of drought.

Precipitation from September 1, 1920, to March 1, 1921, totaled 1.6 inches, while the normal for this period is 5.94 inches. The

[4] This report was prepared by Arthur E. Seamans, who had charge of the dry-land work of the station, being detailed by the Office of Dry-Land Agriculture Investigations of the Bureau of Plant Industry

precipitation from April 1 to August 1 was 7.59 inches, an excess of 0.88 inch above the average. The total precipitation for the year from January 1 to December 31, inclusive, was 12.6 inches, while the average annual rainfall for this period is 13.76 inches. For the year beginning October 1, 1920, and ending September 30, 1921, the rainfall amounted to 11.1 inches as compared with a 10-year average of 14.14 inches, showing a deficiency of 3.04 inches for the past year. This accounts for the scarcity of moisture in the soil at the time of spring seeding and is also responsible in a large measure for the comparatively poor showing made by winter wheat.

Yields of all crops were considerably below the average, and in the case of corn the grain yield was a failure and fodder returns were small.

Winter wheat averaged 11.4 bushels per acre for all methods. The normal return of this crop has been 20.4 bushels per acre. The 1921 average of winter wheat after fallow was 20.1 bushels and after corn 12.4 bushels, while following small grains the average return was a trifle over 3 bushels per acre. As none of this wheat came up before April 4, because of the dryness of the seed bed during the fall and winter, and the maturity of the crop took place during the drought and hot weather throughout July, these yields are considered very satisfactory.

Spring wheat was affected by drought to a greater extent than winter wheat. Though but little moisture was available in the soil at time of seeding, favorable weather and an abundance of rain early in the season was conducive to rapid growth, but the drought caught the crop before it had formed grain, and the result was relatively high yields of straw and low returns of poor quality wheat. The average for all methods was 9.8 bushels per acre as against a normal return for this crop of 15.2 bushels. Summer fallow made an average yield of 18.5 bushels, disked corn ground 10.2 bushels, and wheat after small grains about 3.5 bushels per acre. The season was particularly disastrous to the wheat following small grains when the returns this year were only about one-third the average for former years.

Yields of oats were adversely affected by drought and hot weather. The average yield in 1921 was 19.4 bushels per acre as compared with an 8-year normal of 35.4 bushels. Fallow and disked cornland averaged 39.5 bushels and 23.5 bushels, respectively, while oats after small grains made about 12 bushels per acre.

Barley returns were about 25 per cent of normal, the yields for the past season averaging 6.2 bushels per acre as against 23.1 bushels for former years. Fallow land gave a yield of 15.2 bushels and disked cornland 6.8 bushels per acre. This difference between these methods is somewhat greater than usual, as the average from fallow for all years is 24.8 bushels and for cornland 23.9 bushels. Barley following small grains was practically a failure, as the yield was only about 2 bushels where normally a return of 15 bushels had been obtained.

Flax yields were proportionately low when compared with other crops. The average of all plats was 2.7 bushels as against a normal return of 7.8 bushels. Disked cornland returns exceeded the average from fallow, with yields of 3.2 bushels and 3.1 bushels per acre, respectively. In general, the flax plats were very weedy as a result of poor stands and dry weather.

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Very few of the corn plats produced grain during the past season, but in no case was there a complete failure of forage. The land which made a return of ear corn this year was that which was in corn during 1920. Of the various methods yielding grain, corn on spring-listed ground yielded 14.9 bushels per acre, which was the maximum. The average fodder return for all plats was 392 pounds per acre. This is with one exception (1919) the only time ear corn has not been produced in these experiments. The average returns of corn, including the zero yields of 1919, have been 22.1 bushels of grain and 1,843 pounds of stover per acre for the period from 1913 to 1920, inclusive.

Owing to the drought and ravages of grasshoppers no hay yields could be obtained from the forage plats. This was true to a large extent of the miscellaneous crops, such as beans, garden vegetables, and potatoes, though small yields of the latter crop were harvested for seed.

In the hog-pasturing work no results were possible from the plats of peas and corn, as the crops were destroyed by drought and hail. The 1-acre plat of winter rye, though not coming up until April, carried 10 fall pigs for a period of 35 days from June 8 to July 14, during which time the animals gained a total of 286 pounds at the expense of 984 pounds of corn fed as a supplement to the rye pasture. This pork was made at the rate of 3.44 pounds of corn per pound of gain. The check plat of rye made 5 bushels per acre of grain.

From the rye plat the hogs were moved to the acre plat of Success barley. This crop was about dried up and hence of poor quality as a hog feed. Fourteen days were required to harvest the barley and a gain of 21 pounds of pork was made during the period. The check plat of barley when harvested and threshed yielded 6.4 bushels per acre.

On one-half acre of alfalfa seeded in rows, three pigs made a total gain in weight of 218 pounds in 70 days. During this time they received a ration of corn amounting to 663 pounds, an average of 3.04 pounds of corn for each pound gain of pork. A similar area of alfalfa seeded broadcast was grazed off by three pigs during the same 70 days and returned a gain of 201 pounds of pork for the 663 pounds of corn fed. This was at the rate of 3.3 pounds of corn per pound gain.

Two pigs on a quarter acre of brome-grass sown broadcast made a total of 109 pounds during a 61-day pasture period. This gain was at the rate of 3.24 pounds of corn per pound of pork, a total of 353 pounds of grain being fed as a supplement to the pasture.

One-half acre of brome-grass seeded in rows furnished grazing for three pigs for a total of 70 days. These animals returned a gain of 155 pounds for the period and consumed 621 pounds of corn, or 4.02 pounds of corn for each pound gain in pork.

An extensive series of soil-moisture studies made throughout the season showed only a very small amount of available moisture in the soil at any time during the summer. Where crops were grown on the land, no available moisture remained in the soil after harvest, nor was any accumulated before the date of last sampling, October 27. Land maintained in fallow throughout the season collected a small amount of rainfall, but in general the increase did not extend below the second foot up to the date of final sampling, October 27.

CROP-UTILIZATION EXPERIMENTS.

PASTURING ALFALFA WITH HOGS.[5]

In two of the irrigated crop-rotation experiments, Nos. 67 and 69, the third-year alfalfa is pastured with hogs each year. The season consists of two periods. Fall pigs are used during the spring period, which extends from May to July, and spring pigs are used during the summer period, which extends from July to October.

The plats in these rotations are one-fourth acre in size, and each plat is divided into two equal areas, the hogs being alternated from one area to the other every 10 or 12 days.

The pigs are weighed every 14 days and are fed a daily ration of corn equal to 2 per cent of their total live weight. The plats are pastured at the rate of 2,000 to 2,500 pounds per acre.

In 1921 poor growth of the alfalfa reduced the grazing period to 125 days, which was 19 days less than the average length of the season for the years 1914 to 1921, inclusive. The results obtained in pasturing alfalfa with hogs in rotations 67 and 69 for the eight-year period from 1914 to 1921 are shown in Table 9.

TABLE 9.—*Results of pasturing pigs on alfalfa on the Huntley Experiment Farm during the eight-year period from 1914 to 1921, inclusive.*

[Calculations made on an acre basis.]

Year.	Rotation. No.	Number of pigs.		Number of days.	Weight of pigs (pounds).				Grain fed per pound of gain (pounds).
		Spring.	Summer.		Initial.	Final.	Gain.		
							Total.	Average daily per pig.	
1914	67	16	36	138	3,272	5,572	2,300	0.42	2.78
1915	67	20	32	150	4,364	6,840	2,476	.70	3.13
1916	67	20	32	145	3,520	6,552	3,032	.85	2.79
1917	67	16	36	150	3,280	5,460	2,180	.74	2.87
1917	69	20	32	152	3,288	5,768	2,480	.72	2.64
1918	67	20	32	148	3,200	5,560	2,360	.66	2.72
1918	69	20	32	148	3,216	5,464	2,248	.63	2.85
1919	67	20	32	159	3,720	6,196	2,476	.57	2.99
1919	69	20	32	161	3,700	5,796	2,096	.48	2.45
1920	67	20	32	134	2,812	4,752	1,940	.56	2.57
1920	69	20	32	134	2,772	4,552	1,780	.55	2.83
1921	67	16	32	125	3,860	5,864	2,004	.72	3.06
1921	69	16	32	125	3,868	5,880	2,012	.71	2.93
Average		18.7	32.6	144	3,452	5,698	2,260	.64	2.82

PASTURING CORN WITH HOGS.

The spring pigs used in the alfalfa-pasturing experiment in rotation 67 are used to hog-off a quarter-acre plat of corn in the same rotation as soon as the summer pasturing period of the alfalfa is completed.

Table 10 gives the results obtained from hogging-off corn for the 10 years from 1912 to 1921, inclusive, on a per acre basis.

[5] This report was prepared by Robert E. Hutton, who had charge of the animal-husbandry work of the station, being detailed by the Division of Animal Husbandry, Bureau of Animal Industry.

TABLE 10.—*Results of hogging-off corn on the Huntley Experiment Farm during the 10-year period from 1912 to 1921, inclusive.*

[Calculations made on an acre basis.]

Year.	Number of hogs.	Number of days.	Weight (pounds).				Estimated yield (bushels).
			Hogs.			Grain fed per 100 pounds of gain.	
			Initial.	Final.	Total gain.		
1912	20	16	2,900	3,288	388	530	56.4
1913	16	23	1,312	2,080	768	440	60.0
1914	16	22	1,380	2,276	896	320	50.4
1915	16	25	1,376	2,240	864	450	52.4
1916	16	20	1,516	2,188	672	500	60.0
1917	16	24	1,200	1,828	628	380	43.2
1918	16	27	1,428	2,152	724	510	65.0
1919	16	27	1,636	2,112	476	410	55.0
1920	32	22	2,652	3,444	792	469	66.4
1921	32	18	2,916	3,572	656	609	72.3
Average	19.6	22.4	1,831	2,518	688	462	58.1

In rotation 69, field L–IV, Dwarf Essex rape is drilled between the corn rows about July 20 at the rate of 8 pounds per acre. As a rule, by the time the corn is mature the rape has made a good growth. In 1921, however, owing to grasshopper damage the rape was a complete failure, and the results obtained must be regarded as hogging corn only. Table 11 presents the results obtained from pasturing the rape and corn in rotation 69 during the 6-year period from 1916 to 1921, inclusive.

TABLE 11.—*Results of hogging-off corn and rape on the Huntley Experiment Farm for the 6-year period from 1916 to 1921, inclusive.*

[Calculations reduced to an acre basis.]

Year.	Number of hogs.	Number of days.	Weight (pounds).				Estimated yield (bushels).
			Hogs.			Grain fed per 100 pounds of gain.	
			Initial.	Final.	Total gain.		
1916	8	38	660	1,246	586	485	50.8
1917	16	22	1,168	1,700	532	433	41.4
1918	16	36	1,156	1,964	808	380	55.0
1919	16	29	1,116	1,930	814	241	66.0
1920	32	39	1,198	2,038	840	392	57.7
1921	32	43	1,474	2,228	754	479	64.5
Average	20	25	1,129	1,850	722	402	55.9

TABLE 12.—*Comparison of the results of hogging-off corn for 6 years with rape and for 10 years without rape on the Huntley Experiment Farm.*

[Calculations reduced to an acre basis.]

Item of comparison.	Average results.	
	10 years without rape.	6 years with rape.
Number of hogs per acre	19.6	20
Duration of experiment ... days	22.4	25
Total weight:		
Initial ... pounds	1,831	1,129
Final ... do	2,518	1,850
Gain ... do	688	722
Yield of corn (estimated) ... bushels	58.1	55.9
Estimated grain fed per 100 pounds of gain ... pounds	462	402

A comparison of the results obtained from hogging corn and rape with those of hogging corn without rape shows that there is an advantage in favor of the corn and rape (Table 12). The estimated gain per 100 pounds of grain for the corn and rape is 402 pounds as compared with 462 pounds without rape.

FEEDING EXPERIMENTS WITH HOGS.

Experiments in pork production were started at the Huntley Experiment Farm in 1917. The work is in cooperation with the Division of Animal Husbandry of the Bureau of Animal Industry, United States Department of Agriculture, and the Montana Agricultural Experiment Station. A herd of pure-bred Duroc-Jersey hogs is maintained on the farm to furnish the necessary animals for the investigational work. Several of the more desirable pigs were sold to neighboring farmers for breeding purposes. The experiment conducted in 1921 included (1) a comparison of barley and corn as fattening feeds for hogs, (2) a comparison of various ways of handling fall pigs from weaning time to marketing, (3) the feeding of various grain rations to pigs on alfalfa pasture and finishing in the dry lot, and (4) a comparison of light and heavy pasturing of alfalfa.

CORN COMPARED WITH BARLEY FOR FATTENING HOGS.

This test was conducted with two lots of 12 hogs each; one lot received shelled corn and tankage in different compartments of a self-feeder and the other lot received a self-fed ration of ground barley and tankage. In this test particular attention was paid to the quality of the grains used. The corn fed was a good grade of No. 3 yellow and the barley was a No. 2 brewing barley weighing 47 pounds per bushel and having 11 per cent hulls. The barley was raised under irrigation at the Huntley Experiment Farm. The results obtained are shown in Table 13.

TABLE 13.—*Results of corn compared with barley for fattening hogs on the Huntley Experiment Farm in 1921.*

[Duration of experiment 48 days.]

Item.		Lot 1, corn and tankage self-fed.	Lot 2, ground barley and tankage self-fed.
Average weight per pig:			
Initial	pounds	139.1	133.6
Final	do	212.6	204.1
Gain	do	73.5	70.5
Average daily gain	do	1.53	1.46
Total gain per lot	do	882	845
Feed consumed:			
Corn	do	3,768	.....
Barley	do	.....	4,229
Tankage	do	165	140
Feed per 100 pounds of gain	do	446	517

As shown in Table 13, both lots of hogs made satisfactory gains, but there was considerable difference in the feed required to produce the gain. It required 71 pounds more barley and tankage to produce 100 pounds of pork than it did corn and tankage. On this basis 100 pounds of No. 3 corn is equal in feeding value to 116 pounds of No. 2 barley.

VARIOUS METHODS OF HANDLING FALL PIGS.

On December 29, 1920, three lots of fall pigs were started on a series of tests to determine the most profitable method of management to bring the pigs to a marketable weight. The pigs were pure-bred Duroc-Jerseys farrowed in October and averaged about 50 pounds in weight. Lot 1, consisting of 11 pigs, was placed on a full-feed ration of corn, middlings, and skim milk and marketed in April at a weight of 195 pounds each. Lot 2 was carried through the winter on a limited ration of corn 8 parts, tankage 1 part, and alfalfa hay in the rack. At the beginning of the pasture season this lot was placed on one-half acre of irrigated alfalfa pasture and fed 2 pounds of corn daily for each 100 pounds of live weight. Lot 2 was marketed on July 20 at a weight of 184 pounds each. Lot 3 received the same treatment as lot 2 during the winter season, and at the beginning of the pasture season was placed on three-fourths of an acre of irrigated alfalfa pasture. The pigs received no grain while on pasture except during the last 30 days, when they were fed gradually increasing quantities of corn, so that they were on full feed at the close of the pasture season. This lot of hogs was given a finishing period of 24 days at the close of the pasture season and was marketed on October 22 at an average weight of 214 pounds each. The results obtained are shown in Table 14.

TABLE 14.—*Results of various methods of handling fall pigs on the Huntley Experiment Farm in 1921.*

Item.	Lot 1, full feed, corn 1 part, middlings 1 part, and skim milk 2 parts.	Lot 2, limited winter ration; 2 per cent corn on alfalfa pasture, May to July.	Lot 3, limited winter ration; no grain on alfalfa pasture, May to September; finished in dry lot self-fed.
Number of hogs	11	8	8
Total number of days	114	202	297
Number of days in dry lot	114	145	169
Number of days on pasture	.....	57	128
Area of pasture ... acre	.....	.5	.75
Average initial weight ... pounds	50.2	51.6	46.2
Average weight at close of winter feeding ... do	.....	132.6	114.2
Average weight at close of pasture season ... do	.....	184	159
Average final weight ... do	195.9	184	214.9
Average daily gain ... do	1.28	.65	.56
Feed consumed:			
Corn ... do	3,120	4,120	4,637
Tankage ... do	.....	333	352
Middlings ... do	3,120	.....	.....
Skim milk ... do	6,440	.....	.....
Hay equivalent of pasture ... do	.....	2,396	4,224
Pounds of feed concentrates per 100 pounds of gain	389	420	369
Pasture in terms of hay ... pounds	.....	226	313
Skim milk ... do	389	.....	.....

As will be seen from Table 14, the pigs in lot 1, which were finished as soon as possible, were marketed April 21 at an average weight of 195 pounds each. To produce 100 pounds of gain required 389 pounds of concentrates and an equal weight of skimmed milk.

The pigs in lot 2 were not marketed until July 20. During the winter dry-lot period when the hogs were on a limited ration it required 463 pounds of grain to make 100 pounds of gain. When

the pigs in lot 2 were placed on pasture with a limited ration the average daily gain went from 0.56 to 0.9 pound per day. The average daily ration at the beginning of the pasture period was about the same as the ration fed in the dry lot. Lot 2 while on pasture produced 100 pounds of gain from 354 pounds of corn. The combined results for the two periods for lot 2 show much higher than this, due to the long winter period when the hogs required much more feed to produce the gains. For the average of the two periods it required 420 pounds feed for each 100 pounds of gain. The pigs in lot 2 were fed for 88 days longer than those of lot 1, making additional labor and overhead expense.

The pigs in lot 3 received identical treatment with lot 2 until the close of the winter feeding period. At this date lot 3 was put on pasture and fed no grain until September 1, when the pigs were fed small amounts of grain, increased gradually so that they were on full feed at the close of the pasture period. During the pasture period the pigs in lot 3 produced a gain of 44.8 pounds each and consumed 196 pounds of corn for each 100 pounds of gain. At the close of the pasture season the pigs were given a short finishing period in the dry lot on self-fed corn and tankage. For a period of 24 days they made an average gain of 2.66 pounds daily and required 396 pounds of grain for each 100 pounds of gain.

The results of the finishing period show that the fall pigs came off the alfalfa pasture in excellent shape to make rapid and economical gains in the dry lot. It was readily apparent from watching the pigs on pasture that they were growing a big frame which should enable them to lay on the fat rapidly when they were given a fattening ration. The combined figures for lot 3 show that for the entire period it required an average of 369 pounds of grain for each 100 pounds of gain. It will be seen from Table 14 that the most economical gains were made by lot 3. Comparing lot 3 with lot 1 the results show that the difference in the feed per 100 pounds of gain was only 20 pounds. This small feed difference in favor of lot 3 is more than overbalanced by the much longer feeding period with the additional labor and risk required by the lot.

The results from this series of tests show that where feed is available it is probably better to feed fall pigs for an early spring market. In case it is not desirable to rush the pigs to early maturity, a comparison of lots 2 and 3 shows that it is more economical to carry the pigs through the summer with little or no grain on alfalfa pasture and finish them in the dry lot in the fall than it is to fatten them in the summer months with corn while on alfalfa pasture.

The results obtained in this test of carrying fall pigs through the summer on alfalfa with no grain should not be confused with spring pigs on alfalfa pasture, as repeated trials with spring pigs on alfalfa pasture at this station have shown that spring pigs are not properly nourished on a ration of alfalfa pasture without grain and will not come off the alfalfa in a condition to make profitable gains in the feed lot.

VARIOUS GRAIN RATIONS FOR SPRING PIGS ON ALFALFA PASTURE.

On June 28 five lots of spring pigs were placed on alfalfa pasture and fed varying grain rations to determine the most economical method of raising the pigs to a marketable weight. For comparison

a similar lot of pigs was given a full ration of corn and tankage from a self-feeder but received no pasture. The alfalfa plats were divided into two parts and the hogs changed from one to other about every two weeks to allow for irrigation and the growth of new forage. There were eight pigs in each lot, averaging about 45 pounds each. The outline of the experiment was as follows:

Lot 2, eight pigs on one-fourth acre of alfalfa pasture having access to shelled corn in a self-feeder.

Lot 3, eight pigs on one-fourth acre of alfalfa pasture having access to corn and tankage in different compartments of a self-feeder.

Lot 4, eight pigs on one-fourth acre of alfalfa pasture receiving daily 2 pounds of shelled corn for each 100 pounds of live weight.

Lot 5, eight pigs on one-fourth acre of alfalfa pasture receiving daily 2 pounds of corn and tankage (corn 14 parts, tankage 1 part) for each 100 pounds of live weight.

Lot 6, eight pigs on three-fourths of an acre of alfalfa pasture receiving daily 2 pounds of corn for each 100 pounds of live weight.

Lot 7, eight pigs, similar to those having access to alfalfa pasture, receiving a self-fed ration of corn and tankage in the dry lot.

All lots had access to a mineral mixture. The pigs were weighed on three successive days at the beginning and at the end of the test and also at intervals of two weeks throughout the test. Two one-fourth acre plats of alfalfa adjacent to the pasture were harvested for hay and the average yields taken as the yield on one-fourth acre of pasture. Thus the hay equivalent of the pasture could be estimated and the relative merits of using alfalfa as a pasture or as a hay crop determined.

At the close of the pasture season the pigs were placed in the dry lot and given a self-fed ration of corn and tankage until they reached a marketable weight. The figures for the combined periods are shown in Table 15.

TABLE 15.—*Results showing the combined results of the pasture and dry-lot periods of the spring pigs on various grain rations on the Huntley Experiment Farm in 1921.*

Items of comparison.	Ration.					
	Corn, self-fed.	Corn and tankage, self-fed.	2 per cent corn.	2 per cent corn and tankage.	2 per cent corn.	Corn and tankage, self-fed.
Lot number	2	3	4	5	6	7
Number of hogs	8	8	8	8	8	8
Area of pasture ... acre	¼	¼	¼	¼	¾	None.
Days on pasture	92	92	92	92	92	.....
Days in dry lot	48	48	68	68	54	160
Total days	140	140	160	160	146	160
Days required to weigh 200 pounds	130	134	153	145	140	160
Average initial weight ... pounds	45.5	45.4	46.7	47	45.5	45.6
Average final weight, pasture period ... pounds	123.8	125.8	90.4	95.2	109.4	101
Average final weight, dry lot ... do	211.9	207.6	207.1	215	206.2	200
Total gain per pig ... do	166.4	162.2	160.4	168	160.7	154.4
Total gain per lot ... do	1,331	1,296	1,283	1,346	1,286	1,234
Average daily gain ... do	1.19	1.16	1.0	1.05	1.1	.96
Feed consumed:						
Corn ... do	4,526	4,405	4,590	4,452	4,103	4,711
Tankage ... do	144	173	205	250	174	374
Hay equivalent of pasture ... do	1,240	1,240	1,240	1,240	2,340	.....
Concentrates per 100 pounds gain, pasture period ... do	329	337	294	265	206	459
Concentrates per 100 pounds gain, total period ... do	351	353	374	350	332	412

As shown in Table 15, the pigs that received self-fed corn on pasture required 2 pounds less corn per 100 pounds of gain than did the self-fed corn and tankage lot. The difference in the two lots is so slight that they indicate nothing except that the addition of tankage had no beneficial effect. However, the lot receiving a 2 per cent ration of corn and tankage produced 100 pounds of gain with 24 pounds less feed than lot 4, receiving 2 per cent corn. There is not a great deal of difference in the amount of grain necessary to produce 100 pounds of gain for the total period in the self-fed lots and pasture and the 2 per cent lots. However, the self-fed lots were marketed about 20 days earlier than lots 4 and 5. It will be seen that lot 7, which was on a self-fed ration in the dry lot for the entire period, required more grain per 100 pounds of gain than any of the lots on pasture, and it required a longer period to bring the pigs to a marketable weight. On a basis of the results obtained with lot 7 in the dry lot, the one-fourth acre of alfalfa which was pastured by lot 2 replaced 813 pounds of corn, or produced 177 pounds of gain.

It will be seen that lot 6 was pastured on alfalfa at the rate of eight hogs to three-quarters of an acre, which was only one-third as many hogs per acre as was the case with the other lots. The hogs in this lot made much faster and more economical gains than did the hogs in lot 4, which received identical treatment, except that there were more hogs per acre.

The results from this test indicate (1) that it is more profitable to feed hogs on alfalfa pasture than it is to fatten them in the dry lot; (2) that the addition of tankage to a corn ration on alfalfa pasture has only a slight, if any, advantage; and (3) that pigs will make faster gains and require less grain per 100 pounds of gain if pastured at the rate of 10 or 12 to the acre than if pastured to the full capacity.

EXPERIMENTS WITH DAIRY CATTLE.[6]

Experiments with dairy cattle included pasture carrying-capacity tests and methods of feeding cows under test for advanced registry. In connection with the dairy work, pure-bred Holstein bulls from the experiment farm herd are loaned to farmers locally in the Yellowstone and Bighorn Valleys. Farmers having the use of such bulls are required to keep their herds free from disease, to keep production records of each of their cows, and also to retain in their herds through at least the first lactation period all heifers sired by these bulls. Where herds are small the bulls are often used by several farmers. There are at present 14 bulls in use in 27 herds. This work was begun in 1918, so that there are as yet no yearly records of production of heifers sired by these bulls, although many promising animals are coming into production, and it is evident that this feature of the work will be of much benefit in improving dairy herds in this locality.

PASTURING EXPERIMENTS WITH DAIRY COWS.

Experimental work with irrigated pastures was begun at this station in 1911. The first three years of this line of investigation were devoted to a series of preliminary tests in which a large number

[6] This report was prepared by Thomas W. Moseley, who was detailed by the Dairy Division of the Bureau of Animal Industry to have charge of the work with dairy cattle.

of pasture crops were grown singly and in mixtures. The object of these preliminary tests was to determine which grasses and mixtures appeared to be best adapted to this locality and also to accumulate data as to the best methods of seeding and caring for these crops.

In 1914 this work was enlarged to include an experiment in grazing mixed grass pastures with dairy cows. Since 1914 the grazing tests have held an important place in these investigations. By this means rather definite results as to the number of cows an acre of this pasture will carry and the value of such pastures in milk production have been arrived at. The results of this grazing experiment have shown that well-established pastures of this kind when properly cared for have a carrying capacity of from one and one-half to two cows per acre during a pasture period of from four and one-half to five months. The returns per acre from these pastures have clearly indicated that irrigated land can be profitably used for this purpose.

A rather extensive experiment to ascertain the best method for starting an irrigated grass pasture and also to determine the comparative value of three different grass mixtures was begun in 1916. For this purpose, 24 quarter-acre plats in field L–III were used. The grass mixtures selected for this experiment were those which had appeared most promising in the preliminary tests. These mixtures, designated as Nos. 1, 2, and 3, are presented in Table 16, together with the rate of seeding each of the grasses and clovers. Duplicate plantings of four different seeding methods were made with each of the grass mixtures chosen.

TABLE 16.—*Pasture mixtures and rates of seeding in carrying-capacity test with dairy cattle on the Huntley Experiment Farm in 1921.*

Pasture mixture.	Rate per acre of seeding (pounds).		
	Mixture No. 1.	Mixture No. 2.	Mixture No. 3.
Awnless brome-grass	2	2	.....
Orchard grass	5	5	5
Tall fescue	3	3	3
Perennial rye-grass	3	3	.....
Kentucky bluegrass	4	4	4
White clover	2	.....	2
Alsike clover	2	.....	2
Seed per acre	21	17	16

The results of this experiment have indicated that these grass pastures may be successfully established by seeding in the spring, both with and without a nurse crop of wheat, or they may be sown in grain stubble late in the summer with equal assurance of obtaining a stand.

In 1917 the crop on these plats was cut for hay, and in 1918 a cutting of hay was removed from them before May 22. After this date the plats were used in an experiment to determine the carrying capacity of the various grass mixtures and to ascertain which mixture was best suited for pasturing dairy cattle.

The 2 acres of each pasture mixture were divided so as to form two 1-acre lots. This arrangement permitted a system of alternate

grazing and irrigation of each lot. Three cows were placed on each pasture mixture May 22, and on June 10 a fourth cow was added to each group. This fourth cow was allowed to remain on each pasture mixture until August 22, when she was removed, leaving three cows in each group to complete the season. Each group of cows was as nearly alike as possible in point of milk production, length of lactation period, weight, and date of next calving. Owing to the limited number of cows in milk available for this work, it was necessary to include in each group cows that were dry.

Mixture No. 1 carried two cows in milk and one dry cow, together with a dry cow added June 10 and removed August 22, from May 22 to October 12, a period of 144 days. Mixture No. 3 for the same period supported two cows which were milking part of the season, one cow which was dry the entire season, and a dry cow which was added to the group June 10 and removed August 22. Mixture No. 2 afforded sufficient grazing for three cows producing milk from May 22 to October 2, a period of 134 days. Mixture No. 2 also carried a fourth cow which was dry from June 10 to August 22.

This experiment was conducted in 1919 along the same lines as in 1918, with the exception that when the season opened, May 8, each group was made up of four cows instead of three, as was the case during the previous year. All cows were in milk when the experiment began.

On June 23 one cow was removed from mixtures Nos. 1 and 2, and a similar reduction was made from mixture No. 3 on June 25. Because the pastures were becoming overgrazed, all cows were removed on July 9 for a period of seven days to allow the forage to recover. After being returned to the pastures, each mixture carried three cows until the end of the season, September 28, making a total pasture period of 141 days for the year.

In 1920 four cows were placed on each of the pasture mixtures on May 14. As this number was found to be too small to keep the pastures grazed down, more cows were added to each group on May 17 for varying lengths of time. On July 4 a severe hail and rain storm damaged the pastures to such an extent that it was necessary to remove all the cows from each lot until July 18. After this date each mixture carried three cows for the remainder of the season. Because of inclement weather the cows were not pastured for the three days, August 29 to 31, inclusive.

At the close of the season, September 27, it was found that mixtures Nos. 1 and 3 had provided pasturage for a total of 137 days, while mixture No. 2 carried the cows for 134 days. At the beginning of the season the cows were allotted so that each group contained two dry cows and two cows in milk. For the group on mixture No. 2 this condition held throughout the season, but in the group on mixture No. 1 one of the milking cows went dry August 29 and the same experience was had July 14 with the group of cows on mixture No. 3.

The results obtained from the three-years' test[7] of the carrying capacity of the three pasture mixtures have indicated that mixture No. 3 will support an average of 1.83 cows per day for an average

[7] For a more detailed presentation of the three-years' results of this experiment, see Hansen, Dan, The Work of the Huntley Reclamation Project Experiment Farm in 1920, U. S. Department of Agriculture Circular 204, p. 29, 1921.

period of 141 days. Mixture No. 1 will carry an average of 1.76 cows a day over an average of 141 days also, while mixture No. 2 has given an average return of 1.75 cows for but 136 days of grazing.

THE EFFECT OF BARNYARD MANURE APPLIED AS A TOP-DRESSING ON IRRIGATED GRASS PASTURES.

An experiment outlined to determine what effect barnyard manure may have when applied as a top-dressing to irrigated grass pastures was begun in 1921. For this purpose the duplicate sets of grass pastures seeded in 1916 in field L–III and pastured by dairy cows since 1918 in a carrying-capacity test were used. These plats were refenced so as to divide both of the duplicate sets into two plats of 1½ acres each. This division permitted alternately grazing and irrigating the plats in each set. All plats in both sets were handled alike throughout the season, but during the fall of 1920 the two plats in set A had received a top-dressing of barnyard manure at the rate of 12 loads per acre, while the two plats in set B were untreated.

Six cows were placed on one of the plats in each of the manured and unmanured sets on May 19. As the season advanced, cows were added to or withdrawn from each group as deemed advisable by the condition of the forage. The pastures were irrigated at intervals of 5 to 10 days throughout the season as growth demanded. The six cows with which each pasture was stocked at the beginning of the season were milking during the entire period, but the cows that were used for temporary periods were dry.

When the pasture season closed on October 1, a total of 135 days comprised the grazing period for each of the two pastures. Arranging the data in terms of cow days, the one-year results show the top-dressed pasture, A, to have carried the equivalent of one cow for a period of 415 days, while the untreated pasture, B, supported an equivalent of one cow for 372 days. This is a difference of 43 cow days per acre in favor of the manured pasture, an increase of 11.6 per cent over the pasture receiving no top-dressing. For the 135 days of the grazing season, the A pasture averaged 1.023 cows per acre as against an average of 0.918 cow per acre for the B pasture.

The relatively low carrying capacity of both of these pastures was due largely to the effect of grasshopper invasion. The carrying capacity of these pastures in previous seasons in which no top-dressing of manure was applied was at the rate of over 1.7 cows per acre.

The results obtained from the first year of this experiment are given in Table 17.

TABLE 17.—*Results of pasturing experiments with dairy cows at the Huntley Experiment Farm, comparing pastures receiving a top-dressing of manure with those receiving no top-dressing.*

Items of comparison.	Pasture A (manured).	Pasture B (unmanured).
Length of grazing season.....days..	135	135
Number of cow days per method.....	415	372
Number of grazing days per cow per acre.....	138	124
Average daily number of cows per method for period.....	3.074	2.755
Average daily number of cows per acre.....	1.023	.918

MAXIMUM CARRYING CAPACITY OF AN ACRE OF IRRIGATED PASTURE.

An experiment to determine the maximum carrying capacity of an acre of irrigated grass pasture was begun with dairy cows in 1919. The land used for this purpose was an acre plat in field A, which had been seeded to grass mixture No. 1 in 1916 and top-dressed with barnyard manure at the rate of 12 loads to the acre each year from 1917 to 1921, inclusive. As has been done in all the pasturing tests, the plat was divided so as to permit the alternate grazing and irrigating of each half of the pasture throughout the summer.

The pasture season for 1919 began May 8, and two cows were carried on the acre until September 28, a period of 141 days. The grazing was continuous with the exception of the week beginning July 9, when the cattle were removed in order to allow the forage to

FIG. 2.—Cows on irrigated pasture, Huntley Experiment Farm, 1921.

recover from overgrazing. The cows used in this experiment were giving milk during all but seven days of the season.

In 1920 the season began May 14 and ended September 27, a period of 137 days. Two cows were carried on the pasture for the whole period, and a third cow was used for eight days beginning May 16. Of the cows used, one was giving milk throughout the season; one went dry on August 20; while the third cow used for the 8-day period was giving milk during the time she was on the experiment.

TABLE 18.—*Carrying capacity of an acre of irrigated pasture on the Huntley Experiment Farm in 1919, 1920, and 1921.*

Items of comparison.	1919	1920	1921	Average.
Length of grazing season.....day..	141	137	135	137
Number of grazing days.....	279	282	242	267
Average number of cows per acre.....	1.98	2.06	1.79	1.94
Number of days on outside pasture.....	.....	6	5	.....
Alfalfa hay fed while off pasture.....pounds..	768	750	1,222	913
Green corn fed while off pasture.....do....	.....	.....	1,850	.....

The 1921 pasture season extended from May 19 to September 30, a total of 135 days. (Fig. 2.) Continuous grazing, with the exception of five days, was afforded 1.79 cows giving milk during the time they were on the pasture. The length of the 1921 pasture period was not only shortened but the carrying capacity for the acre was decreased because of the damage done the forage by grasshoppers, which were present in unusual numbers throughout the summer.

Table 18 gives the data obtained for the three years this experiment has been under way.

METHODS OF FEEDING DAIRY CATTLE.

Experimental work to determine the relative economy of production of cows receiving full feed of grain and roughage as compared to roughage alone was begun in 1918. To date four cows have completed a year's production under each system of feeding. The cows were milked three times daily and tested under the rules of the Holstein-Friesian Advanced Registry. The cows while on roughage test received such feeds as alfalfa hay, silage, and roots. The roots were sugar beets and half-mangels. Cows on the full-feed test received in addition to the above-mentioned roughages a grain mixture composed of corn, oats, wheat bran, and linseed meal. During both tests they were on pasture as many days as climatic and pasture conditions would permit.

The production and feed consumption of the four cows that have completed both tests are shown in Table 19.

TABLE 19.—*Results of yearly production and feed consumption of cows on full feed and on roughage without grain at the Huntley Experiment Farm.*

Cow No.	Test made.	Feed consumed (pounds).					Production.	
		Hay.	Silage.	Roots.	Days and nights of pasture.	Grain.	Milk.	Butterfat.
208	Roughage	9,339	8,680	4,620	126 D 34 N	....	11,023.4	388.832
208	Full feed	9,694	7,170	4,620	70 D 7 N	 5,358	14,154.5	430.480
1	Roughage	7,755	7,798	2,745	128 D 77 N	....	12,401.4	486.363
1	Full feed	9,569	6,280	4,815	71 D 7 N	 5,929	15,129.2	523.230
211	Roughage	8,715	10,956	2,030	123 D 10 N	....	15,122.1	488.511
211	Full feed	10,414	7,915	4,625	107 D 140½ D	6,261	20,345.9	638.536
204	Roughage	9,014	8,985	.....	98 N	.....	14,212.1	470.030
204	Full feed	10,039	8,325	4,230	130 D	7,056	25,499.4	823.110

This table indicates that the cows while on full feed consumed less silage and more alfalfa hay than when on the roughage test. The variation in the amounts of roots consumed is due to the variation in the supply of roots available for feeding. The cows at all times consumed all the roots that were fed to them. The table also indicates that under average conditions the milk and butterfat were produced more economically on the roughage ration. In comparing the relative economy of the two systems of feeding on a dollar-and-cents

basis it is necessary to consider the relation between prices of roughage, grain, milk, and butterfat. Where prices of milk are relatively high and prices of roughages are also high it might be more economical to feed larger quantities of grain than in localities where the reverse condition exists. Where butterfat is sold and roughages are low in price the amount of grain that can be profitably fed is a question that must be decided in each locality. However, the results would indicate that when cheap alfalfa hay and corn silage are available the most economical butterfat production is attained when roughage and only a limited grain ration is fed.

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